REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	9/15/95	Progress - 10/1/94 - 9/30/95

4. TITLE AND SUBTITLE

Nonlinear Circuits and Neural Networks

5. FUNDING NUMBERS

N00014-89-J-1402

6. AUTHOR(S)

Leon O. Chua, Professor of Electrical Engineering

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

The Regents of the University of California
c/o Sponsored Projects Office
336 Sproul Hall
Berkeley, CA 94720-5940

8. PERFORMING ORGANIZATION REPORT NUMBER

1-442427-23055

9. SPNSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research
Ballston Tower One
800 North Quincy Street
Arlington, VA 22217-5660

10. SPONSORING /MONITORING AGENCY

11. SUPPLEMENTARY NOTES

n/a

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for Public Release
Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Several results in the area of complex dynamics of arrays of nonlinear dynamical systems have been obtained, including sufficient conditions for synchronization, estimates of dimensional characteristics of 2D patterns, effects of sidewall forcing on Turing patterns and bifurcation scenarios of nonautonomous chaotic circuits.

A CNN universal machine cell was designed in VLSI technology. Several image enhancement, filtering and compression CNN algorithms were developed. Several mathematical problems and models were implemented on the CNN architecture, including the Navier-Stokes equations, mathematical morphological operators, cellular automata, models of population dynamics, models of pattern formation and models of optical illusions.

14. SUBJECT TERMS	15. NUMBER OF PAGES
	2
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

Annual Progress Report on Nonlinear Dynamics Research

Synchronization in arrays of nonlinear dynamical systems

Sufficient conditions for an array of linearly coupled nonlinear dynamical systems to synchronize were derived. A corollary of these conditions is the intuitive idea that sufficiently large dissipative coupling will synchronize the array. These conditions were also cast in graph-theoretical terms by exploiting the connection topology of the array.

Complex dynamics in arrays of nonlinear dynamical systems

Dimensional characteristics of two-dimensional patterns arising in two-dimensional arrays of coupled systems were estimated from the dimensional characteristics of a one-dimensional array of observables.

Hexagonal Turing patterns in a CNN array of active cells were studied under sidewall forcing.

Three-dimensional straight and twisted scroll waves were generated in a three-dimensional spatially discrete medium consisting of a CNN array of active cells..

Transmission of waves through a one-dimensional array of coupled nonlinear oscillators has been studied in detail via physical experiments.

Bifurcation and Chaos

The chaotic dynamics of the simplest dissipative non-autonomous chaotic circuit which we have discovered were studied in detail.

The bifurcation scenario and the devil staircase structure in the forced Chua's oscillator were studied in depth. Applications to signal transmission were shown.

Theoretical foundations

A unified framework for synchronization and control of nonlinear dynamical systems, in particular chaotic systems, was developed. Its usefulness in designing chaotic communication systems and analyzing both chaotic control and chaotic synchronization schemes was shown.

Annual Progress Report on CNN Research

VLSI chip design

A CNN Universal Machine cell was designed with local memories and local logic units. This cell is the basic structuring element of the CNN Universal Machine.

Image enhancement

Real-time NTSC TV image resolution enhancement and color edge correction algorithms were developed.

Fast CNN algorithms were created for facsimile processing which give superior quality output.

Study was done on de-blurring of images by CNN. The results were applied to microscopy.

Mathematical applications

The Navier-Stokes equations, describing the behavior of a largely incompressible fluid, were implemented on the CNN.

The existence of the solitary wave phenomena in the spatially discrete CNN medium was demonstrated.

Both binary and gray-scale mathematical morphological operators with arbitrary structuring element sets were implemented on CNN.

Analog combinatorics tasks (histogram calculation, sorting gray-scale values, determining the parity, and calculation of the majority vote) were developed and implemented on the CNN. The minimum Hamming distance calculation is also implemented.

Cellular automata

Cellular automata were efficiently realized on the CNN Universal Machine.

Linear filtering and Pattern formation

Methods for design of robust IIR zero-phase linear 2D filters were developed.

Pattern formation study dealing with the relationship between the CNN and the Turing mechanism was done.

Image compression

Studies were done on high compression rate still and movie image compression using CNN.

Other applications and studies

A fast automatic layout designer of analogic CNN algorithms was developed.

Several optical illusions were implemented on the CNN proving the similarity of the structure of the human visual system and the Cellular Neural Network.

A population dynamics model was developed and implemented on the CNN.